Evaluation of Data Retention and Imprint Characteristics of FRAMs Under Environmental Stresses for NASA Applications

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A major reliability issue for all advanced nonvolatile memory (NVM) technology devices including FRAMs is the data retention characteristics over extended period of time, under environmental stresses and exposure to total ionizing dose (TID) radiation effects. These advanced memories are mostly available as commercial-off-the-shelf (COTS) devices and often use latest submicron technologies, new dielectric materials, multi-layer interconnect processes, and advanced plastic packaging. In the NVMTS 2001, data retention and fatigue characteristics of 64Kb PZT- based FRAMs from Ramtron Corp., tested over temperature range from –85°C to +310°C for ceramic packaged parts and from –85°C to +175°C for plastic parts, during retention periods of up to several thousands hours, were reported. The observed data retention failures were divided into three categories: (1) random failures that were not related to stress conditions, (2) weak cell failures, which were also not related to a particular stress condition but were reproducible from test to test, and (3) intrinsic failures that were caused by thermal degradation (or wearout) of the ferroelectric cell material. A conclusion was that additional testing should be performed on higher density 256 Kb FRAMs.

For this additional testing, 256 Kb FRAMs in 28-pin plastic DIPs, rated for industrial grade temperature range of –40°C to +85°C were procured. These are two-transistor, two-capacitor (2T-2C) design FRAMs. In addition to data retention characteristics, the parts were also evaluated for imprint failures, which are defined as the failure of cells to change states (e.g., from 1 to 0, or 0 to 1) and is somewhat similar to hysteresis effect.

These 256K FRAMs were subjected to scanning acoustic microscopy (C-SAM); 1000 temperature cycles from –65°C to +150°C; high temperature aging at 150°C, 175°C, and 200°C for 1000 hours; highly accelerated stress test (HAST) for 500 hours; 1000 hours of operational life test at 125°C; and total ionizing dose radiation testing. As a preconditioning, 10K read/write cycles were performed on all devices. Interim electrical measurements were performed throughout this characteization, including special imprint testing.

Failures were observed during high temperature aging test at 200°C, during HAST testing, and during 1000 hours of operational life at 125°C. The parts passed 20 Krad exposure, but there were failures during post- 30 Krad electrical measurements. Test results and failures analysis will be presented in the final report.